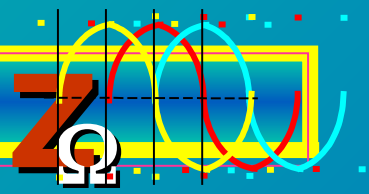
LCR Circuits

UNCLASSIFIED:

2 Hour Conference W/2 Hr PE1

Safety & Environmental Impact: “ LOW ”



Terminal Learning Objective

ACTION:

Calculate Impedance, applied voltage of a Ckt containing resistors, inductors & capacitors.

Given Are Ckt schematics, of a High & low Pass Filters, & Ckt operating concepts.

CONDITIONS:

With Official OMEMS Training Aid reference. {White }

STANDARD:

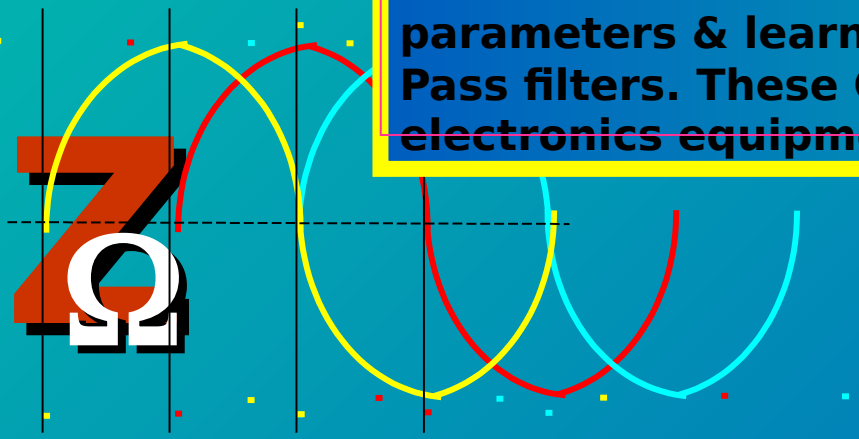
To minimum of 7 out of a possible 10 correct answers.

AC: LCR Circuits

Introduction

In previous lessons you learned of Inductive & Capacitive Ckts Concepts & how to calculate the operating parameters of each of them individually.

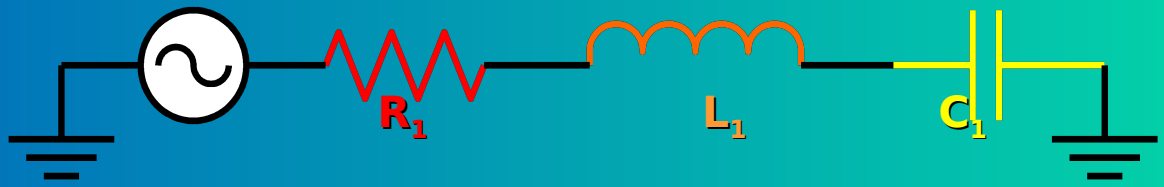
In this lesson we will combine all three devices in one Ckt & calculate its operating parameters & learn the Concepts of a Low & High Pass filters. These Ckts are used extensively in electronics equipment.



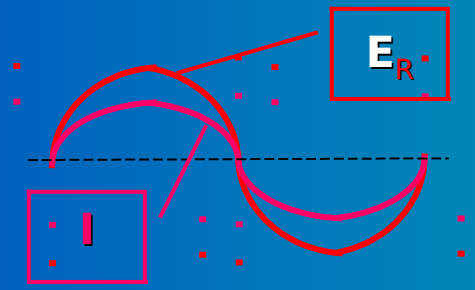
Phase R & I

AC: LCR Circuits

LCR: A Ckt comprised of an Inductor, Capacitor & Resistor.

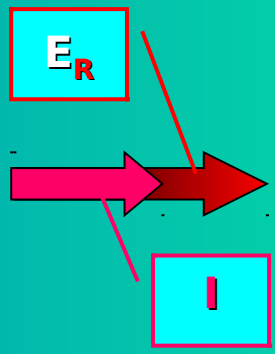


AC Resistor Concepts:



Resistors in an AC Ckt are <u>not</u> reactive to changes in Frequency.

Voltage & Current are in Phase.



Phase L & C

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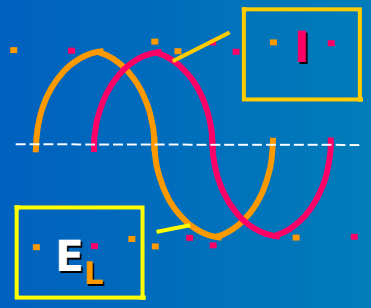
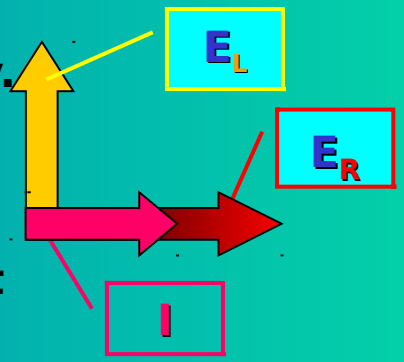
AC Inductor Concepts;



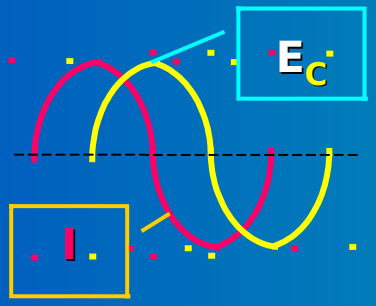
Inductors in an AC Ckt are reactive to changes in Frequency.

Voltage & Current are 90° Out of Phase.

Voltage leads Current by 90°.



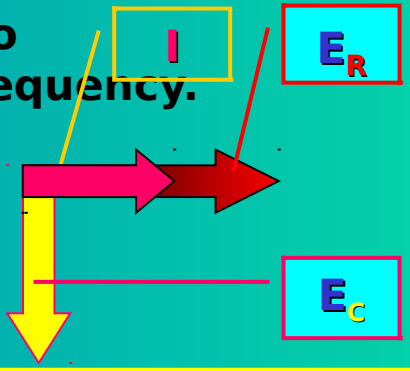
AC Capacitor Concepts;



Capacitors in an AC Ckt are reactive to changes in Frequency.

Current & Voltage are 90° Out of Phase.

Current leads Voltage by 90°.



XL & XC

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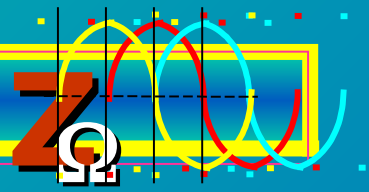


AC Inductor Concepts; Because Inductors are frequency reactive devices their opposition changes w/ the change in Freq, the Inductive Reactance [opposition] must be calculated for.

Ω

$$X_L = 2\pi \times Freq \times Ind$$

Direct Relationship w/Freq

Freq ⇑ XL ⇑ EL ⇑

AC Capacitor Concepts; Capacitors are frequency reactive devices their opposition changes w/ the change in Freq, the capacitive Reactance [opposition] must be calculated for.

Ω

$$X_C = \frac{1}{2\pi \times Freq \times Cap}$$

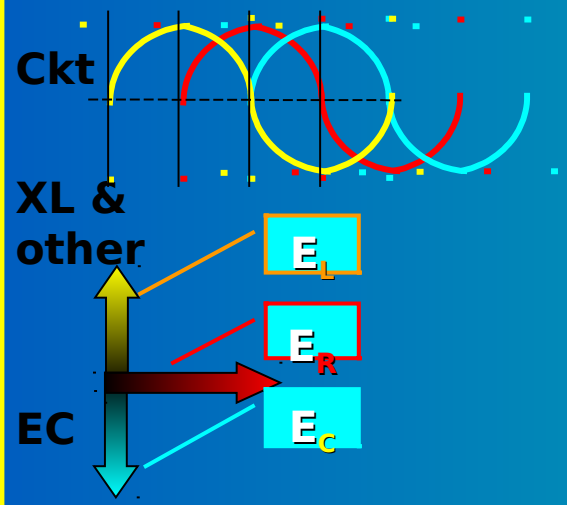
Indirect Relationship w/Freq

Freq ⇑ XC ⇓ EC ⇓

LCR Phase

AC: LCR Circuits

LCR Concepts;



When all three devices are in the same a 180° Phase relationship exists.

Because of this relationship, when the XC are Equal, they will cancel each out.

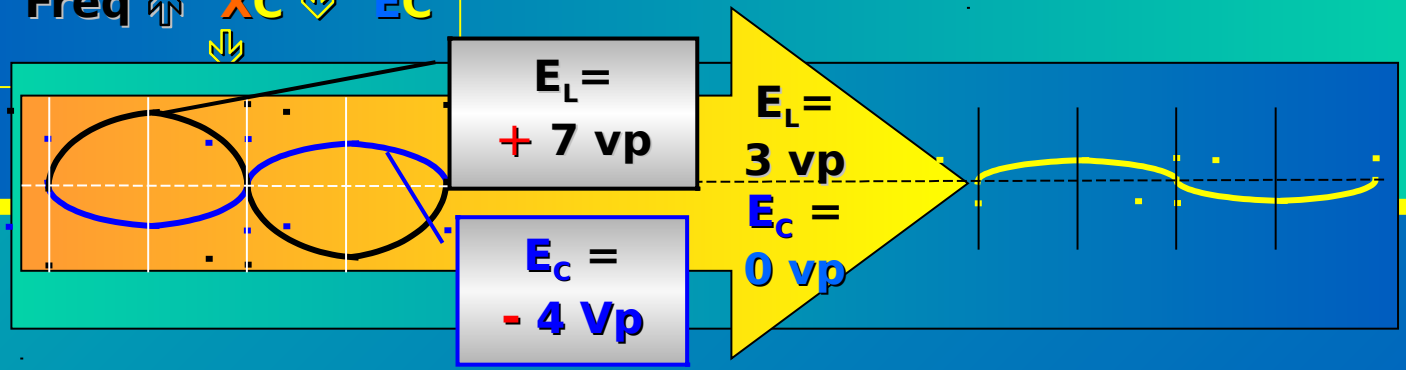
Because of the Direct relationship of opposition & Voltage drops, The EL & will cancel each other out.

If one of the devices has more or Voltage Drop than the other cancel out the one w/the least, & the Greater will dominate the Ckt.

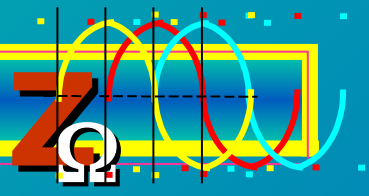
Opposition it will

Freq ⇑ XL ⇑ EL ⇑

Freq ⇑ XC ⇓ EC ⇓



AC: LCR Circuits



Impedance; Is the total Opposition to AC, Unit Ω.

Because of the 180° Out Phase relationship of XL & XC the difference must be the calculated.

If they are Equal, they will cancel each other and only Resistance remains out,

Formula;

$$Z = \sqrt{RT^2 + \{ XL - XC \}^2}$$

Mathematical Order of Precedence, Memory Aid;

Please Excuse My Dear Aunt Sally

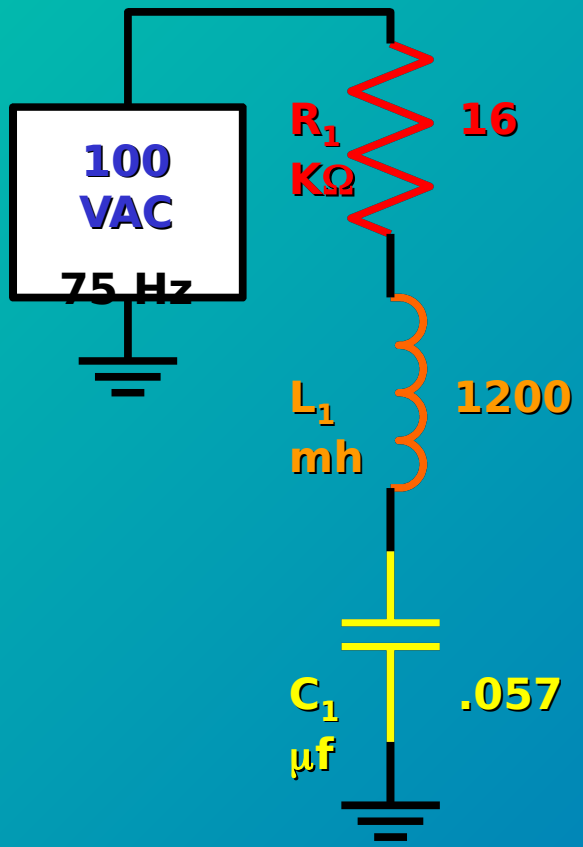
{ } X^2 X ÷ + -

1. Parentheses 2. Exponent 3. Multiply 4. Divide 5. Add 6. Subtract

Z Challenge

AC: LCR Circuits

Impedance; Calculate Opposition parameters;



R_T = _____

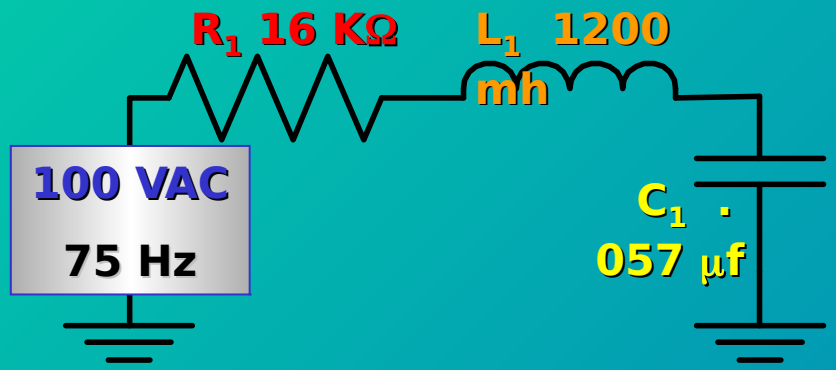
XL_T = _____

XC_T = _____

Answers;

AC: LCR Circuits

Impedance; Calculate Impedance.



$R_T = 16\ K\Omega$

$XL_T = 565.2\ \Omega$

$XC_T = 37.24\ K\Omega$

$Z = _____$

$$Z = \sqrt{RT^2 + \{XC - XL\}^2}$$

$$XC - XL = X^2 + RT\ X^2 = \sqrt{X}$$

$$Z = \sqrt{16\ K\Omega^2 + \{37.24\ K\Omega - 565.2\ \Omega\}^2}$$

$$\sqrt{36.674\ K\Omega^2}$$

$$\sqrt{256^{-6} + 1.34^9}$$

$$\sqrt{1.596^9} \quad Z = 40.01$$

$37.24\ EE^3 - 565.2 = X^2 + 16\ EE^3\ X^2 = \sqrt{X} \Rightarrow Z = 40.013K\Omega$

Answers; Z

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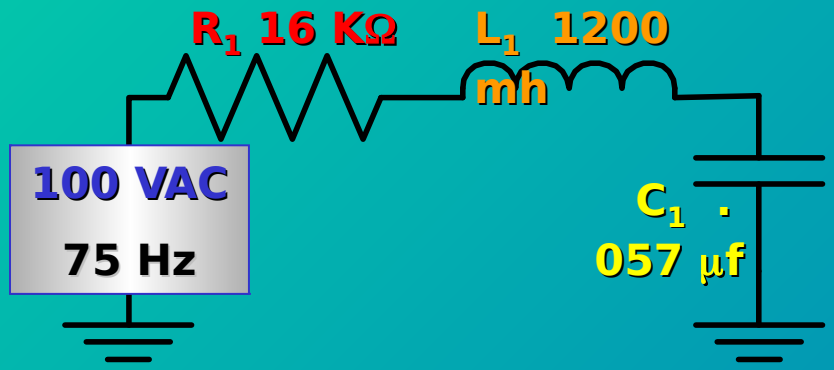
Calculate; IT & the respective Voltage Drops.



R_T = 16 KΩ

XL_T = 565.2 Ω

XC_T = 37.24 KΩ

Z = 40.01 KΩ Carry Decimal 3 Places

I_T = _____

E_{R1} = _____

E_{L1} = _____

E_{C1} = _____

$$Z = \sqrt{RT^2 + \{XC - XL\}^2}$$

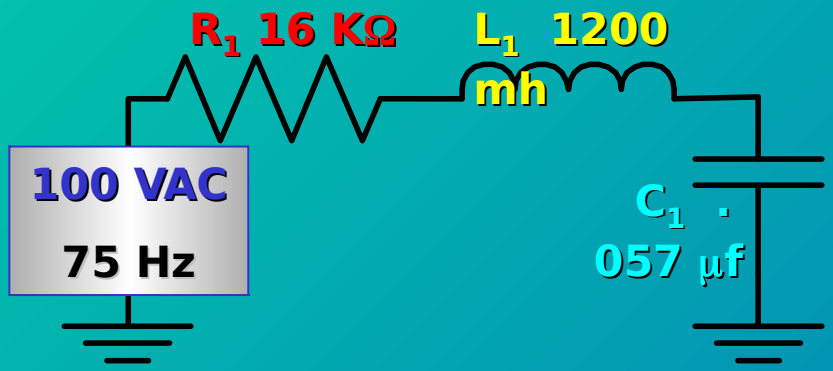
$$XC - XL = X^2 + RT \; X^2 = \sqrt{X}$$

37.24 EE 3 – 565.2 = X² + 16 EE3 X² = √X ⇒ Z = 40.013KΩ

Answers; IT & ER#

AC: LCR Circuits

Calculate Applied Voltage, EA.



$R_T = 16\ K\Omega$

$XL_T = 565.2\ \Omega$

$XC_T = 37.24\ K\Omega$

$Z = 40.01\ K\Omega$

$I_T = 2.512\ mA$

$E_{R1} = 40.19\ V$

$E_{L1} = 1.41\ V$

$E_{C1} = 93.54\ V$

$EA = _____$

$$Z = \sqrt{RT^2 + \{ XC - XL \}^2}$$

$$EA = \sqrt{ER^2 + \{ EC - EL \}^2}$$

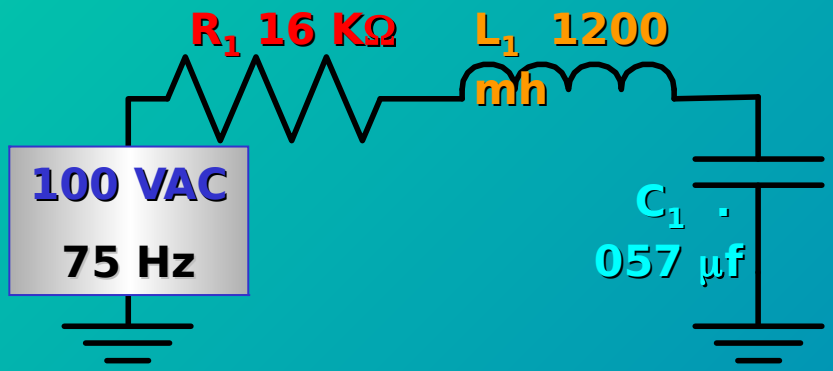
$$EC - EL = X^2 + ER \quad X^2 = \sqrt{X}$$

$$93.54 - 1.41 = X^2 + 40.19 \quad X^2 = \sqrt{X} \Rightarrow EA = _____$$

EA Answer

AC: LCR Circuits

Calculate Applied Voltage, EA.



$R_T = 16\ K\Omega$

$XL_T = 565.2\ \Omega$

$XC_T = 37.24\ K\Omega$

$Z = 40.01\ K\Omega$

$I_T = 2.512\ mA$

$E_{R1} = 40.19\ V$

$E_{L1} = 1.41\ V$

$E_{C1} = 93.54\ V$

$EA = 100.51\ V$

$$Z = \sqrt{RT^2 + \{ XC - XL \}^2}$$

$$EA = \sqrt{ER^2 + \{ EC - EL \}^2}$$

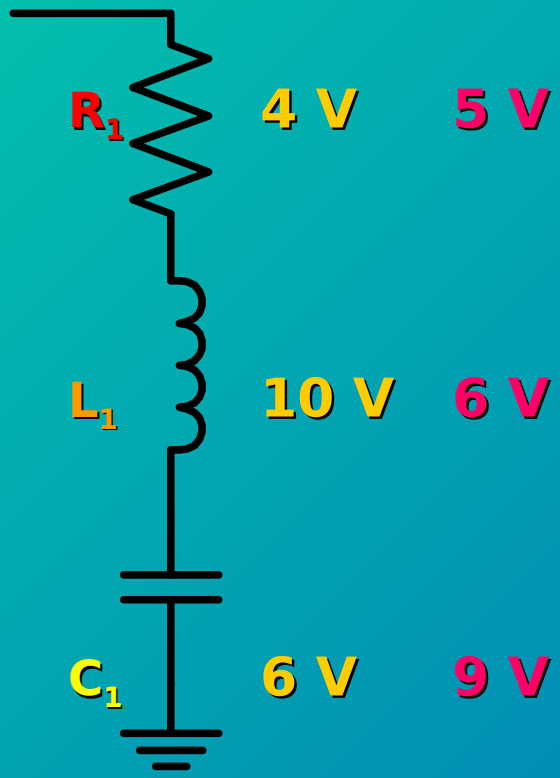
$$EC - EL = X^2 + ER \quad X^2 = \sqrt{X}$$

$$93.54 - 1.41 = X^2 + 40.19 \quad X^2 = \sqrt{X} \Rightarrow EA = 100.51 \text{ VAC}$$

EA Challenge

AC: LCR Circuits

Calculate Applied Voltage, EA & EA.



EA = _____

EA = _____

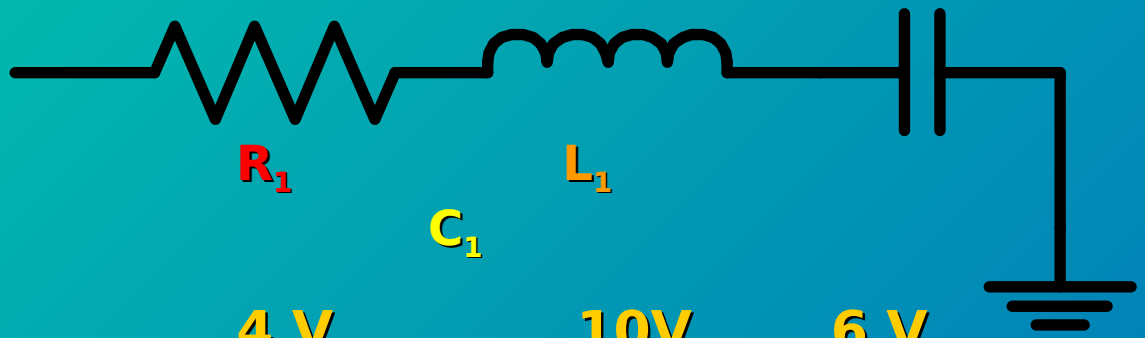
$$EA = \sqrt{ER^2 + \{EC - EL\}^2}$$

$$EC - EL = X^2 + ER \quad X^2 = \sqrt{X}$$

Answers

AC: LCR Circuits

Calculate Applied Voltage, EA & EA.



$10\ V - 6\ V = X^2 + 4\ V \quad X^2 = \sqrt{\ } X \quad \Rightarrow \quad EA = 5.65\ V$

$9\ V - 6\ V = X^2 + 5\ V \quad X^2 = \sqrt{\ } X \quad \Rightarrow \quad EA = 5.83\ V$

$EA = \sqrt{\ } ER^2 + \{ EC - EL \}^2$

$EC - EL = X^2 + ER \quad X^2 = \sqrt{\ } X$

High Pass Filter

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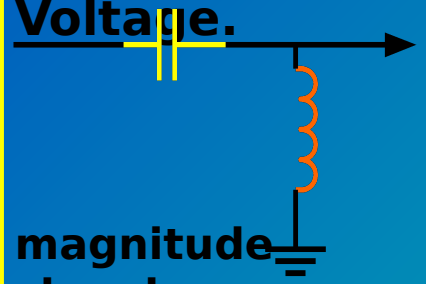
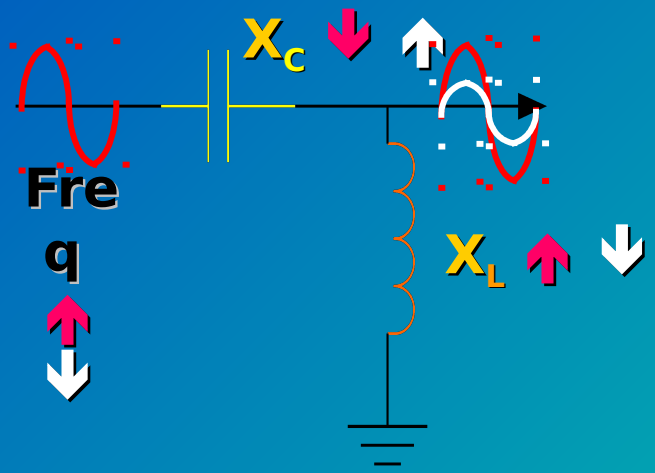
FILTERS; 2 types, High Pass & Low Pass.

High Pass Filter; Passes high frequency W/Maximum Voltage.



Attenuates the low Freq.

Attenuation is the Reduction in magnitude of any electrical parameter of a signal.



Passing the High;

1. X_C ↓ acts like a Short.
2. X_L ↑ Acts like an Open

Attenuates the Low;

1. X_C ↑ acts like a Open.
2. X_L ↓ Acts like an Short

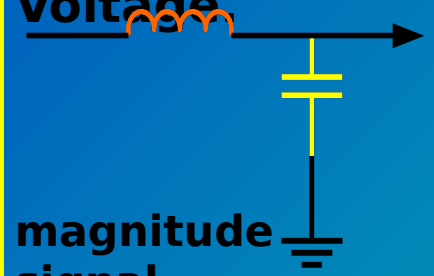
Reference: White Gov Tng Aid, panel C.

Low Pass

AC: LCR Circuits

FILTERS; 2 types, High Pass & Low Pass.

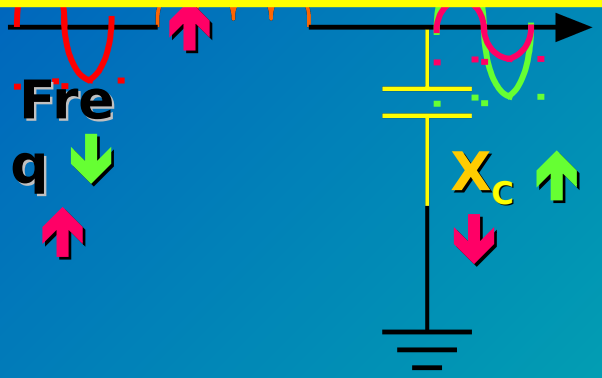
Low Pass Filter; <u>Passes Low frequency</u> W/Maximum Voltage.



<u>Attenuates the High</u> Freq.

Attenuation is the Reduction in magnitude of any electrical parameter of a signal.

The Output is taken across the Capacitor.



1. X_C ↑ acts like a Open.
2. X_L ↓ Acts like an Short.

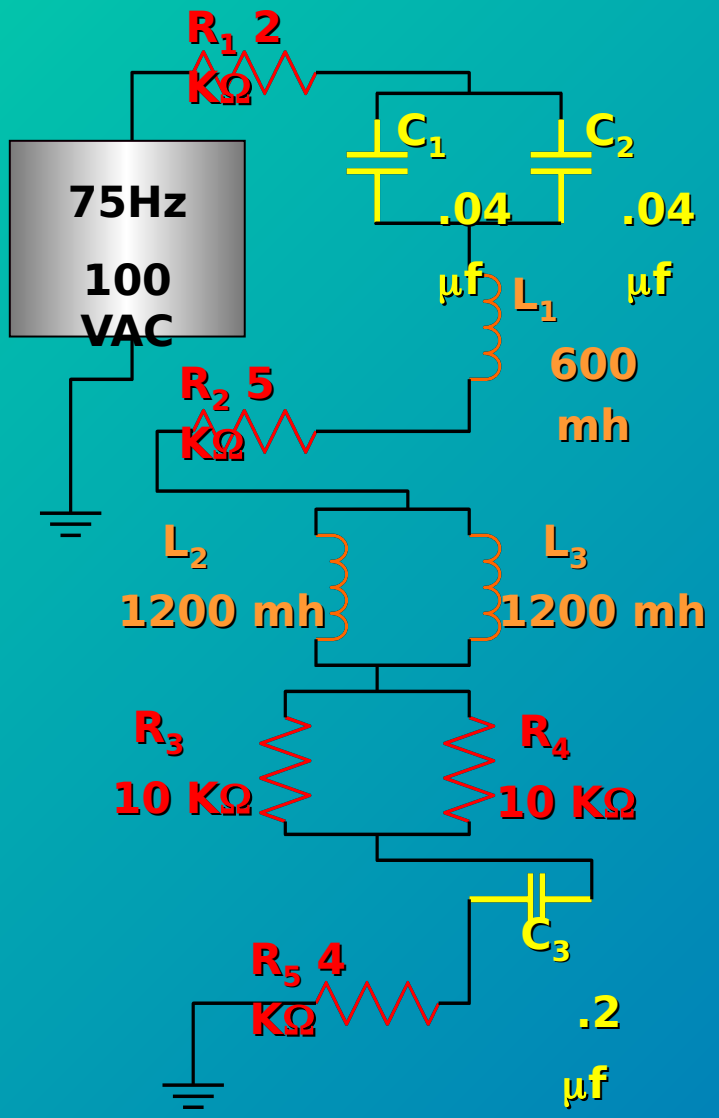
Attenuates the High;

1. X_C ↓ acts like a Short.
2. X_L ↑ Acts like an Open

Reference: White Gov Tng Aid, panel C.

AC: LCR Circuits

Master Challenge; **Calculate the operating parameters.**



$X_{LT} = 2\pi FL$

$X_{CT} = 1/ 2\pi FC$

$R_T = R1+2+ REQ + 5$

$Z = \sqrt{RT^2 + \{ XC - XL \}^2}$

$I_T =$ EA / Z 3 Decimal places

$E_{R1} =$

$E_{R2} =$

$E_{REQ} =$ $E_{RT} =$

$E_{R5} =$

$E_{CEQ} =$ $E_{CT} =$

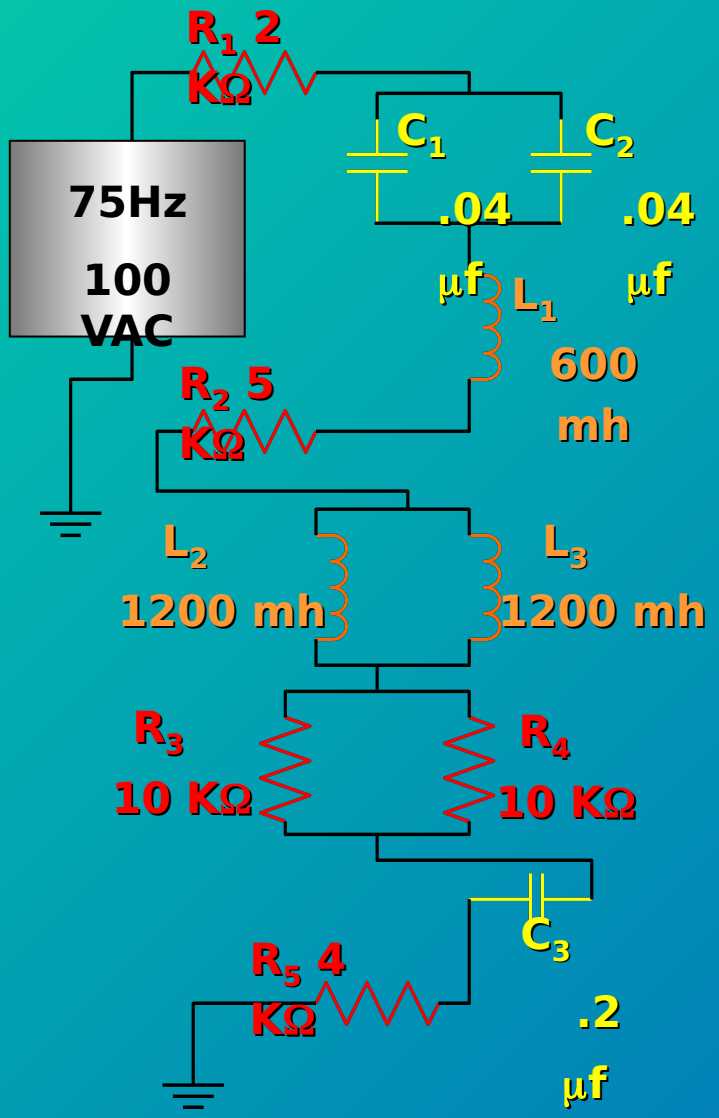
$E_{C3} =$

$E_{L1} =$ $E_{LT} =$

Answers; XLT - IT

AC: LCR Circuits

Master Challenge; Calculate the ER1, ER2, EREQ & ER5.



X_{LT} = 565.2 Ω

X_{CT} = 37.24 KΩ

R_T = 16 KΩ

Z = 40.01 KΩ

I_T = 2.512 mA

E_{R1} = IT X R1

E_{R2} = IT X R2

E_{REQ} = IT X REQ

E_{R5} =

E_{RT} = .

E_{CEQ} =

E_{C3} =

E_{CT} = .

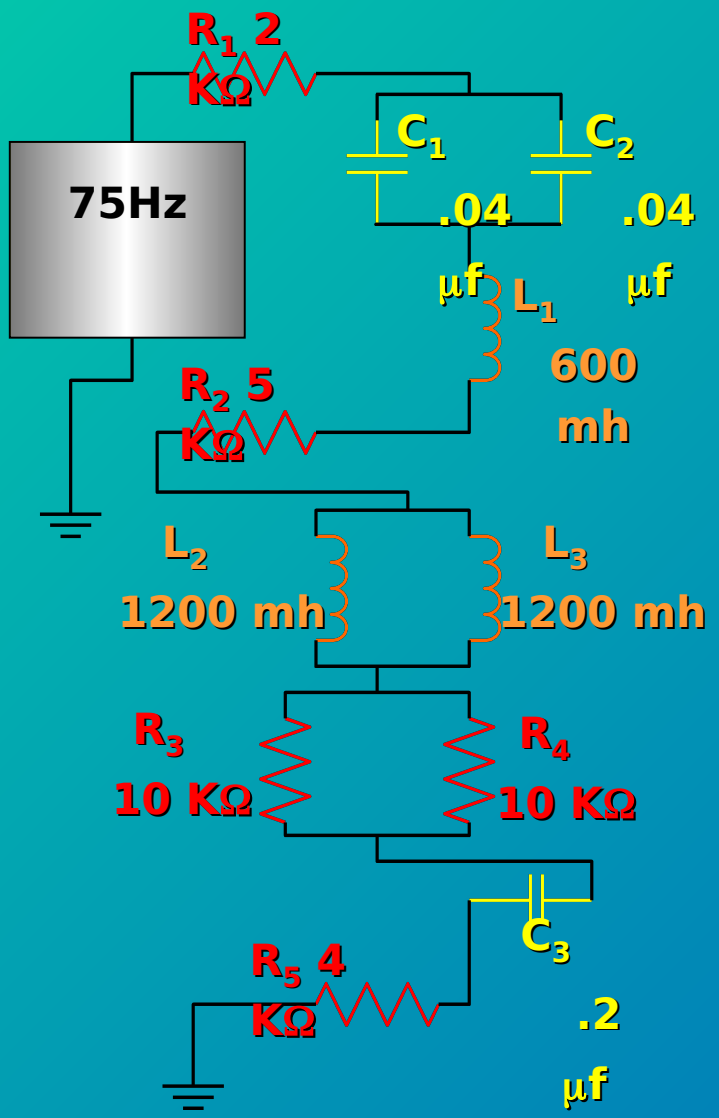
E_{L1} =

E_{LT} = .

Answers; ER

AC: LCR Circuits

Master Challenge; Calculate ECEQ & EC3.



X_{LT} = 565.2 Ω

X_{CT} = 37.24 KΩ

R_T = 16 KΩ

Z = 40.01 KΩ

I_T = 2.512 mA

E_{R1} = 5 V

E_{R2} = 12.5 V

E_{REQ} = 10 V

E_{RT} = 40 V

E_{R5} = IT X X_{CEQ}

E_{CEQ} = IT X X_{C3}

E_{CT} =

E_{C3} =

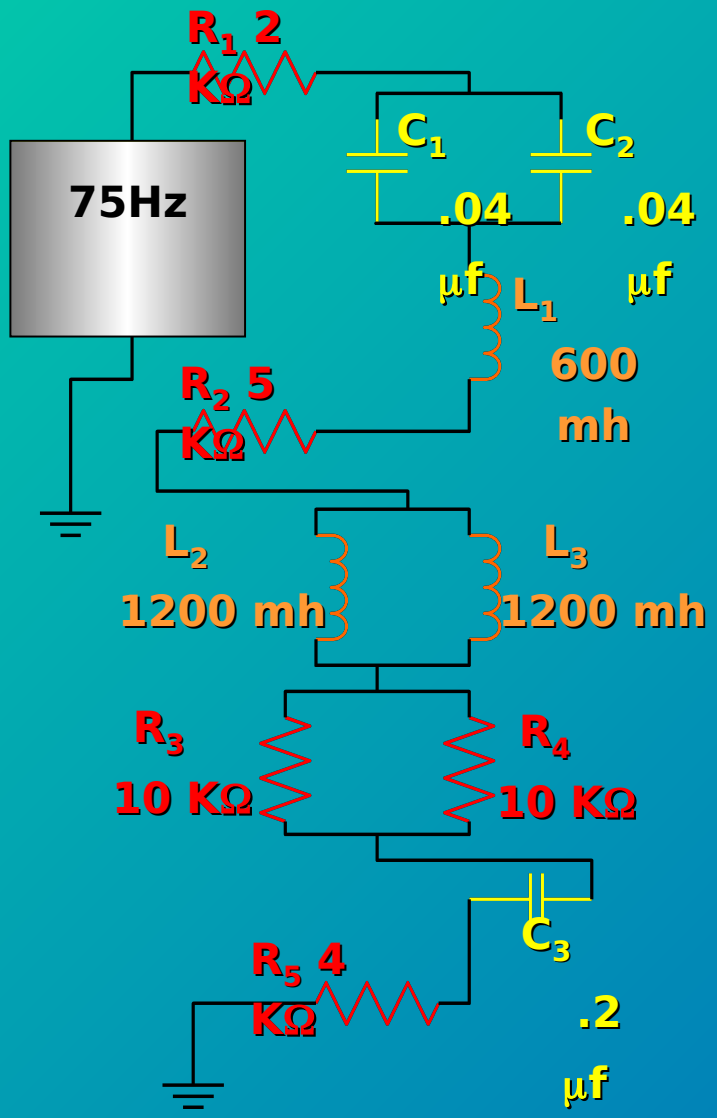
E_{L1} =

E_{LT} =

Answers; EC

AC: LCR Circuits

Master Challenge; Calculate the EL & ELEQ.



X_{LT} = 565.2 Ω

X_{CT} = 37.24 KΩ

R_T = 16 KΩ

Z = 40.01 KΩ

I_T = 2.512 mA

E_{R1} = 5 V

E_{R2} = 12.5 V

E_{REQ} = 10 V

E_{RT} = 40 V

E_{R5} = 66.25 V

E_{CEQ} = 26.5 V

E_{CT} = 92.75 V

E_{C3} = IT X X_{L1}

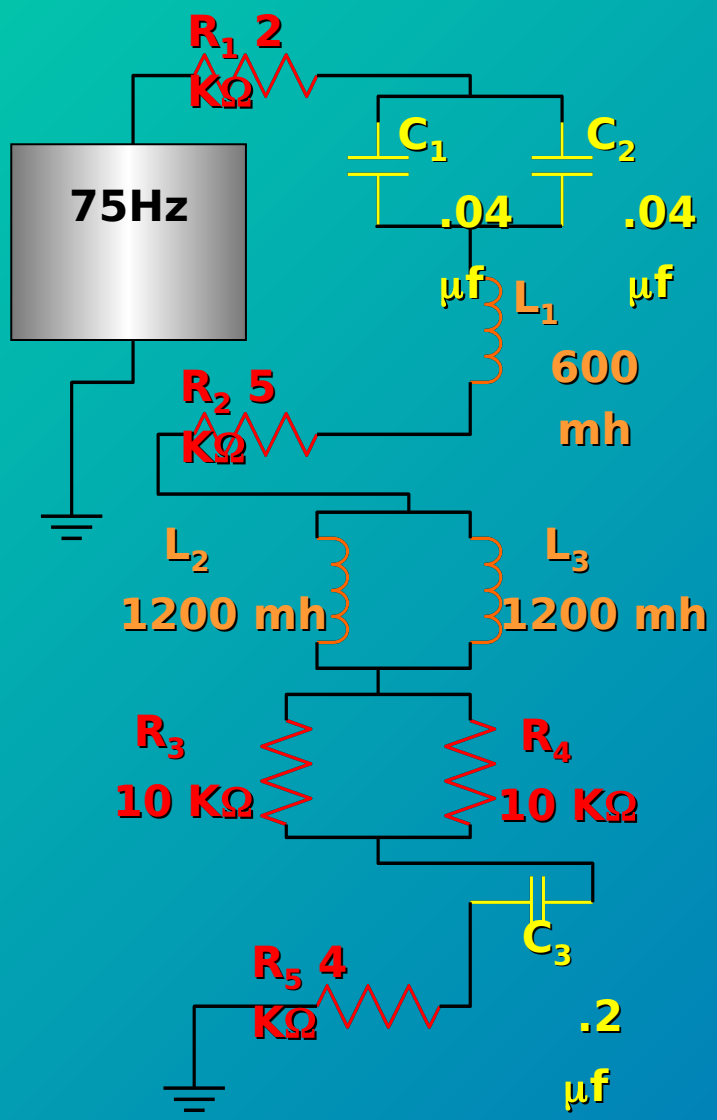
E_{L1} = IT X X_{LEQ}

E_{LT} =

Answers; EL

AC: LCR Circuits

Master Challenge; Calculate For the Applied Voltage, **EA**.



X_{LT} = 565.2 Ω

X_{CT} = 37.24 KΩ

R_T = 16 KΩ

Z = 40.01 KΩ

I_T = 2.512 mA

E_{R1} = 5 V

E_{R2} = 12.5 V

E_{REQ} = 10 V

E_{RT} = 40 V

E_{R5} = 66.25 V

E_{CEQ} = 26.5 V

E_{CT} = 92.75 V

E_{C3} = .7 V

E_{L1} = .7 V

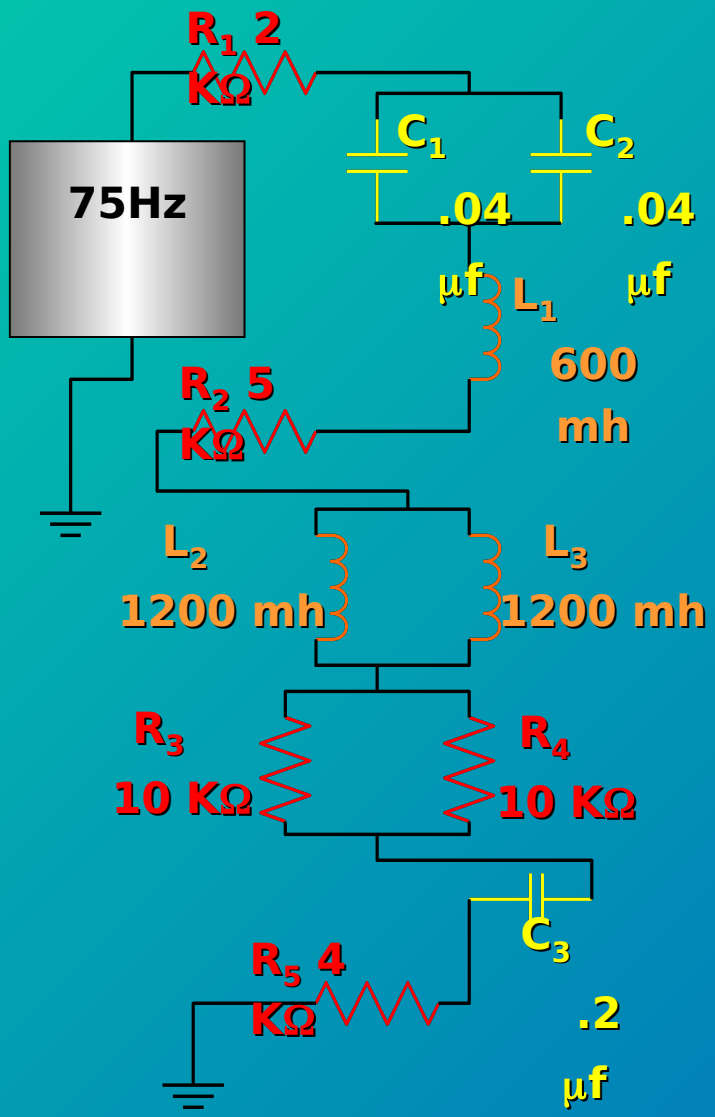
E_{LT} = 1.41 V

$$EA = \sqrt{ER^2 + \{EC - EL\}^2}$$

Answers; EA

AC: LCR Circuits

Master Challenge; Calculate For the Applied Voltage, EA.



X_{LT} = 565.2 Ω

X_{CT} = 37.24 KΩ

R_T = 16 KΩ

Z = 40.01 KΩ

I_T = 2.512 mA

E_{R1} = 5 V

E_{R2} = 12.5 V

E_{REQ} = 12.5 V

E_{RT} = 40 V

E_{R5} = 10 V

E_{CEQ} = 66.25 V

E_{CT} = 92.75 V

E_{C3} = 26.5 V

E_{L1} = .7 V

E_{LT} = .7 V

EA = 99.7 to 100.51 V

Close

AC: LCR Circuits

SUMMARY & QUESTIONS:

LESSON TEST:

Time; **20 Minutes.**

References; **Official OMEMS Training Aids.**

Standard; **7 of 10 correct answers.**